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SOYBEAN APHID MANAGEMENT UPDATE: WHAT TO SELECT FROM A VARIETY OF PEST MANAGEMENT TOOLS?

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Introduction

Soybean aphid experience in Iowa: Like most of the Midwest, Iowa soybean growers were introduced to a new pest when the soybean aphid, *Aphis glycines* Matsumura (Homoptera: Aphididae), arrived in 2000. And like many other states, Iowa has experienced large populations of aphids (> 2,000/plant) in two of the past five years that the aphid has been in the state (Lang 2003, M. O'Neal unpublished). Although not well understood, there is an apparent oscillation in aphid populations between years with large populations occurring in 2001 and 2003, and low populations ($\leq$500 aphids per plant) occurring in 2002 and 2004.

During 2003 soybean aphid populations in Iowa began to sharply increase early in June (Rice 2003) and by July, over 2,000 aphids per plant reported when plants were in full bloom to early pod set (DeWitt and Tollefson 2003). In total, an estimated 4 million acres in Iowa were treated with insecticide to control soybean aphid populations (Landis et al. 2003). In a remarkable reversal, we experienced very low populations of soybean aphids during 2004, with many of our research sites experiencing peak populations of less than 100 aphids per plant (fig 1). Given the oscillating trend, and the appearance of soybean aphids overwintering on buckthorn within central Iowa (M. O'Neal unpublished data), soybean aphid populations may be larger in 2005.

Soybean Aphid Biology Soybean aphid has a complex lifecycle with sexual stages found on the primary host plant (Rhamnus spp., buckthorn), and asexual stages occurring on the secondary host plant, soybean (Wang et al. 1962). Soybean aphids migrate to R. cathartica from soybean fields, where a sexually reproductive generation produces eggs that overwinter on the plant. In the spring, these eggs hatch and eventually producing alates (winged adults) that migrate back to soybean, arriving in early to mid June (Rice 2003, Fox 2002). Soybean aphids reproduce asexually while on soybeans, increasing their numbers rapidly. Natural enemies can play a key role in suppressing soybean aphid populations both in its native Asia (Liu et al. 2004) and the North Central US (Fox et al. 2004, Rutledge et al. 2004). In Asia, where soybean aphids are rarely a pest, coccinellids (ladybird beetles) are among the most common natural enemies, and soybean aphid colonies typically support parasitism rates of 40% (Liu et al. 2004). Iowa soybean fields contain many aphid predators (Bechinski and Pedigo 1981), yet large populations of aphids have occurred in two of the past four years that the aphid has been in the state (Lang 2003, M. O'Neal unpublished data).

Soybean Pest Managemen in Iowa- more than just one pest In Iowa, management of soybean aphids is complicated by a 5-year trend of increasing bean leaf beetle, ***Cerotoma trifurcata***, populations (Krell et al. 2003). Both present growers with two potential sources of yield loss from direct feeding as well as disease infection as both bean leaf beetle and soybean aphid are vectors of several plant viruses (Clark and Perry 2002). In Iowa, evaluation of the effect of the current recommendation for bean leaf beetle (Bradshaw and Rice 2003) on soybean aphid population management is being conducted. Several foliar applied insecticides can reduce soybean aphid populations (Ostlie 2002), and insecticides applied as seed treatments may slow soybean aphid establishment and population growth (C. DiFonzo, pers. comm.). Given that these insecticides are active against both bean leaf beetles and soybean aphid, there is the potential that both could be managed within the same program. A management strategy based on an early and mid-season application of Warrior can manage bean leaf beetle and may reduce incident of bean pod mottle virus (Bradshaw and Rice 2003). Whether a mid-season application of Warrior timed with the emergence of the first generation of bean leaf beetle is effective for controlling soybean aphids is not yet known.

Soybean Aphid Management Many questions have yet to be answered regarding the successful management of soybean aphid, including establishing economic thresholds, timing and method of insecticide application. In Iowa, the Soybean Entomology laboratory is attempting to address several of these issues. In this report we summarize our data from the 2004 field season regarding three projects that address:

1) effectiveness of prophylactic treatments for soybean aphids
2) importance of coverage and active ingredient on insecticide performance against soybean aphids
3) impact of bean leaf beetle management programs on soybean aphid management, and
4) development of economic thresholds for soybean aphid management

1. Effectiveness of prophylactic treatments for soybean aphids

Following the large soybean aphid populations of 2003, during the spring of 2004 there was grower interest in the prophylactic use of insecticides as seed treatments or tank-mix combinations with post-emergence herbicides. In Iowa, bean leaf beetle pressures have resulted in a section 18 labeling of neonicotinoid seed treatments for soybeans. There was also some discuss of the potential of an insecticide applied with a post-emergent herbicide to provide protection against soybean aphids (Rice 2004). Potentially convenient, these practices may have drawbacks. Insecticide residual activity may not be sufficient to provide sufficient protection against soybean aphids that arrive in late July. This residual activity may also be reduced by poor coverage of an insecticide that is applied as a herbicide. To reduce the potential for drift, herbicides are applied with lower pressure and larger droplet size than insecticides.

Prophylactic insecticide treatments have several drawbacks. First, insecticide residual activity may not provide sufficient protection against soybean aphids that arrive in July and August. Also, most current post-emergence herbicides are applied with lower pressures than insecticides to control for drift. We were interested in how applying an insecticide as one would a herbicide (herbicide best practice = HBP) affects aphid control versus applications as one would an insecticide (insecticide best practice = IBP). The four treatments included an 1) untreated control, 2) a seeds treated with a neonicotinoid insecticide (imidacloprid, Gaucho, Bayer Cropscience), and a pyrethroid (lambda-cyhalothrin, Warrior, Syngenta) applied with a 3) poster emergent herbicide (HBP) or an 4) as one would an insecticide (IBP). The HBP and IBP treatments were applied using a backpack sprayer (See Table 1 for sprayer configuration for HBP and IBP).

Due to low field populations treatments were applied well below threshold. The impacts of these treatments were assessed by artificially infesting leaves. Twenty leaves were collected from each treatment, and a single 1 day old aphid was placed on a leaf within a Petri dish. Aphid survivorship was observed every 24 to 48 hours for a 10 day period. Treatment effects were determined using a repeated measures ANOVA.

Table 1. Configuration of insecticide application.

Insecticide (oz/acre)	Nozzle	Total GPA	Pressure (psi)	Notes
Warrior (3.2)	TeeJet 8002XR	10	20	Pyrethorid applied with herbicide best practice (HBP)
Warrior (3.2)	TeeJet 11002 TwinJet	20	40	Pyrethroid applied with insecticide best practice (HBI)
Lorsban (24)	TeeJet 11002 TwinJet	20	40	Organophosphate applied with IBP
Baythroid (2) and Lorsban (4)	TeeJet 11002 TwinJet	20	40	Pytrethroid tank mix applied with IBP

Results Overall, each form of insecticide application reduced soybean aphid survival ($F = 41.8$, $df = 3, 76$; $P = 0.001$) when leaves were artificially infested. In comparison to the foliar-based insecticide, we measured the seed treatments efficacy 45 days after planting. Despite this delay the mortality of aphids on leaves from seed treated plants was still greater than that of the untreated control (Fig. 1). Within the ten days that we tracked aphid survival, the foliar-applied insecticide had the greatest impact regardless of application form (HBP or IBP).

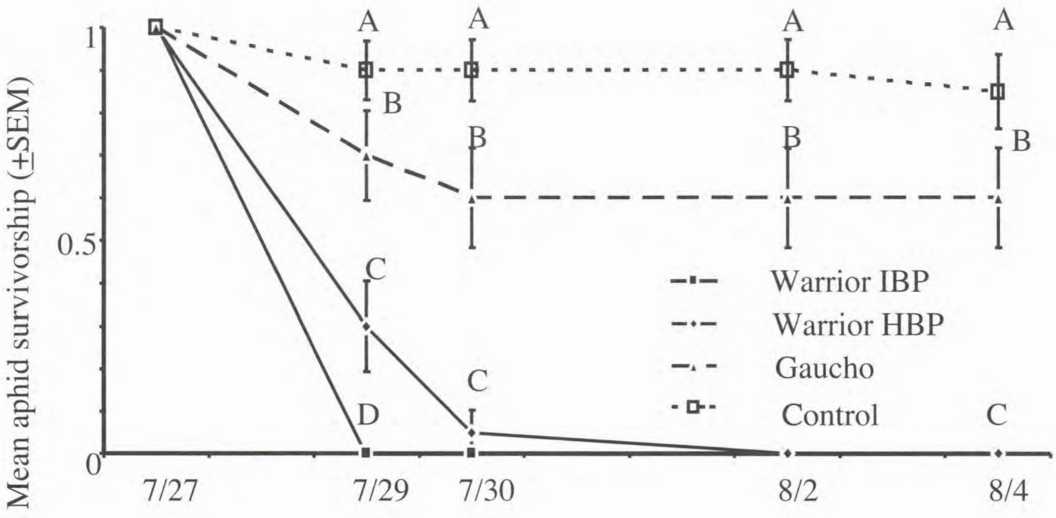

Figure 1. One day after Warrior treatment and 47 days after treatment/planting of Gaucho treated seed. No difference in aphid mortality was observed between HBP and IBP after 7/30.

2. Importance of coverage on insecticide performance against soybean aphids.

Materials and Methods Although soybean aphids were low throughout most of Iowa, we did identify a field that was above threshold (> 250 aphids/plant) in southern Iowa at the McNay Research and Demonstration farm in Chariton County. We used this site to expand upon the importance of spray coverage on soybean aphid mortality and the effectiveness of insecticide treatments for soybean aphid management. Unlike in the previous section, these plots were natural infested. Plots measuring 3 by 10 m were arranged within a complete randomized block design consisting of four replications of each treatment. In addition to an untreated control, we compared the efficacy of an organophosphate (Lorsban) alone, this organophosphate in combination with a pyrethroid (Baythroid) and a pyrethroid (Warrior) applied alone. This last treatment was applied using the HBP and IBP methods. Refer to table 1 for details of the insecticide application methods for each treatment.

Five consecutive plants were counted from a randomly selected site from each replication, and complete aphid counts were performed on these plants. Initial aphid counts were taken on 6 August 2004 before treatments were applied. All treatments were applied using a 3 m, 3pt mounted sprayer on a 6000 series John Deere tractor. Boom height was set at 6 cm above the canopy and ground speed was ~3mph. Subsequent aphid counts were next taken on 12, and 20 August 2004, and the effect of each treatment on accumulated aphid days was analyzed using ANOVA.

Results Initial aphid populations were above 250 aphids per plant and did not vary significantly across plots before application of treatments (fig. 2a). After insecticide application, untreated soybean aphid populations increased and were above 250 aphids per plant for 6 days (fig. 2b) and 14 days (fig. 2c) after treatment. Each insecticide applications reduced aphid populations below the untreated treatment (fig 2b and 2c). However, when Warrior was applied using HBP, soybean aphid populations were an intermediate density between Warrior applied using IBP and the untreated control. Although the HBP reduced populations below 250 aphids per plant 6 days after treatment (Fig. 2b), plants within this treatment accumulated over 1000 aphid days after treatment.

3. Determine the effect of bean leaf beetle management tactics on soybean aphid population growth.

Materials and Methods Several insecticides can reduce soybean aphid populations (Ostlie 2002), including two pyrethroids, Asana (esfenvalerate, DuPont) and Warrior (lambda-cyhalothrin, Syngenta), which are also labeled for use against bean leaf beetles. The seed treatment Cruiser (thiamethoxam, Syngenta) may also slow soybean aphid establishment and population growth (C. DiFonzo, pers. comm.). Whether these insecticides can provide protection from soybean aphid when they are applied with the emergence of the overwintering generation or first generation of bean leaf beetle is not yet known. For example, such a program may help actually increase the rate of soybean aphid establishment and population growth by removing the natural enemies of soybean aphids

We used the following experimental design, originally developed for the comparison of chemical control tactics for early season bean leaf beetle management. These tactics comprise eight treatments; 1) Cruiser seed treatment (50 g/cwt), 2) Cruiser and Warrior (3.2 oz/a, 10d post emergence of plants), 3) Cruiser and Warrior (3.2 oz/a, at emergence of 1st bean leaf beetle generation), 4) Warrior (2.5 oz/a, at 10d post plant emergence), 5) Warrior (3.2 oz/a at emergence of 1st bean leaf beetle generation), 6) Warrior (2.5 oz/a, at 10d post plant emergence and 3.2 oz/a at emergence of 1st bean leaf beetle generation), 7) Asana (7.7 oz/a at 10d post plant emergence and 9.6 oz/a at emergence of 1st bean leaf beetle generation), 8) untreated control.

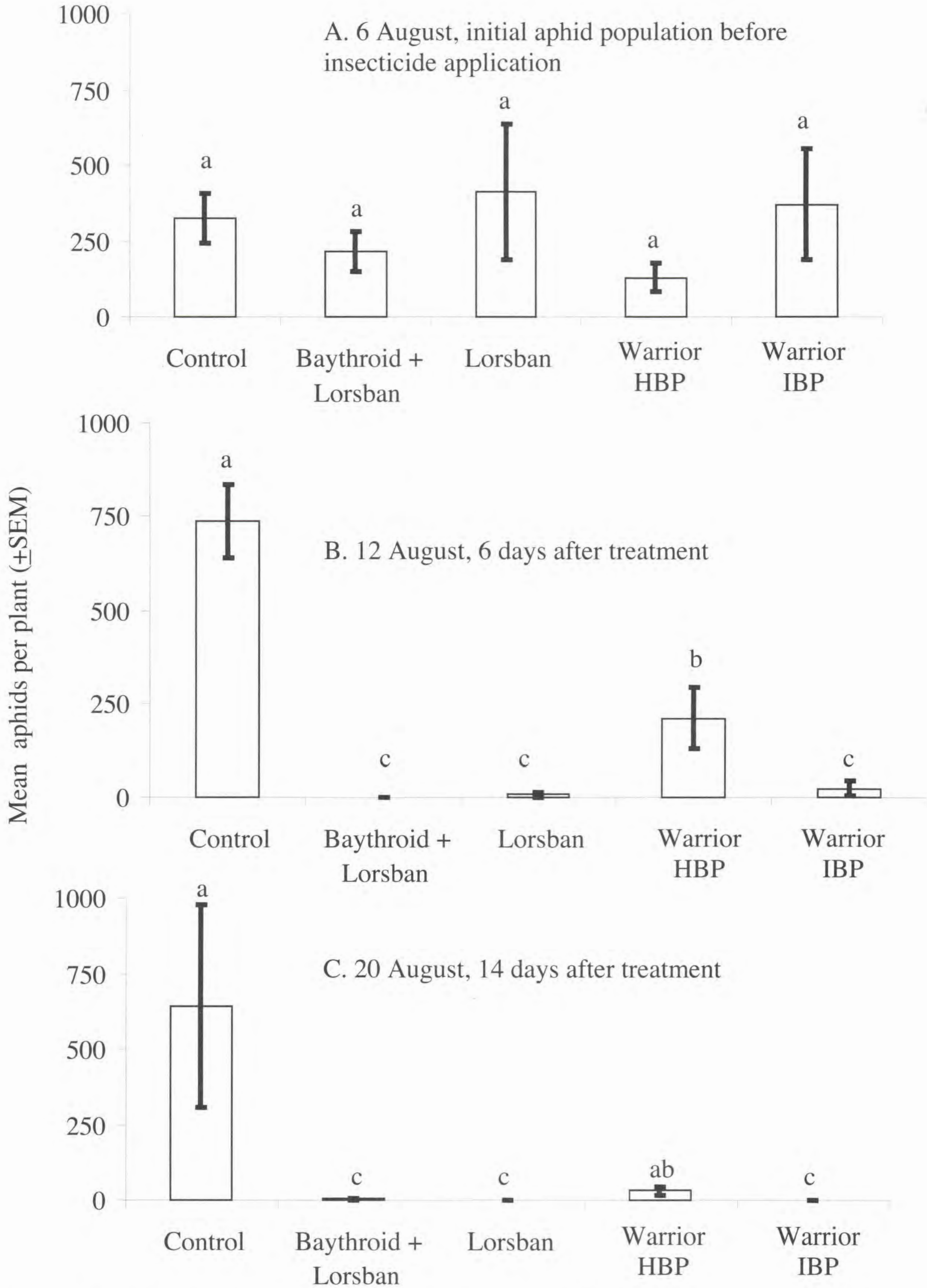

Figure 2. Insecticide coverage impacts soybean aphid populations. Insecticide applied with high pressure and small droplet size (IBP), except for HBP which was applied as a herbicide with low pressure and large droplet size. See table 1 for sprayer configuration, and rates. Means labeled with a unique letter were significantly different (P=0.05).

Soybean were planted on 3 May with each treatment applied to 8 replications in a randomized complete block design at Iowa State University Research and Demonstration farm in Story County. Soybean aphids were sampled each week using the method described above and the effect of each treatment on accumulated aphid days was analyzed using ANOVA.

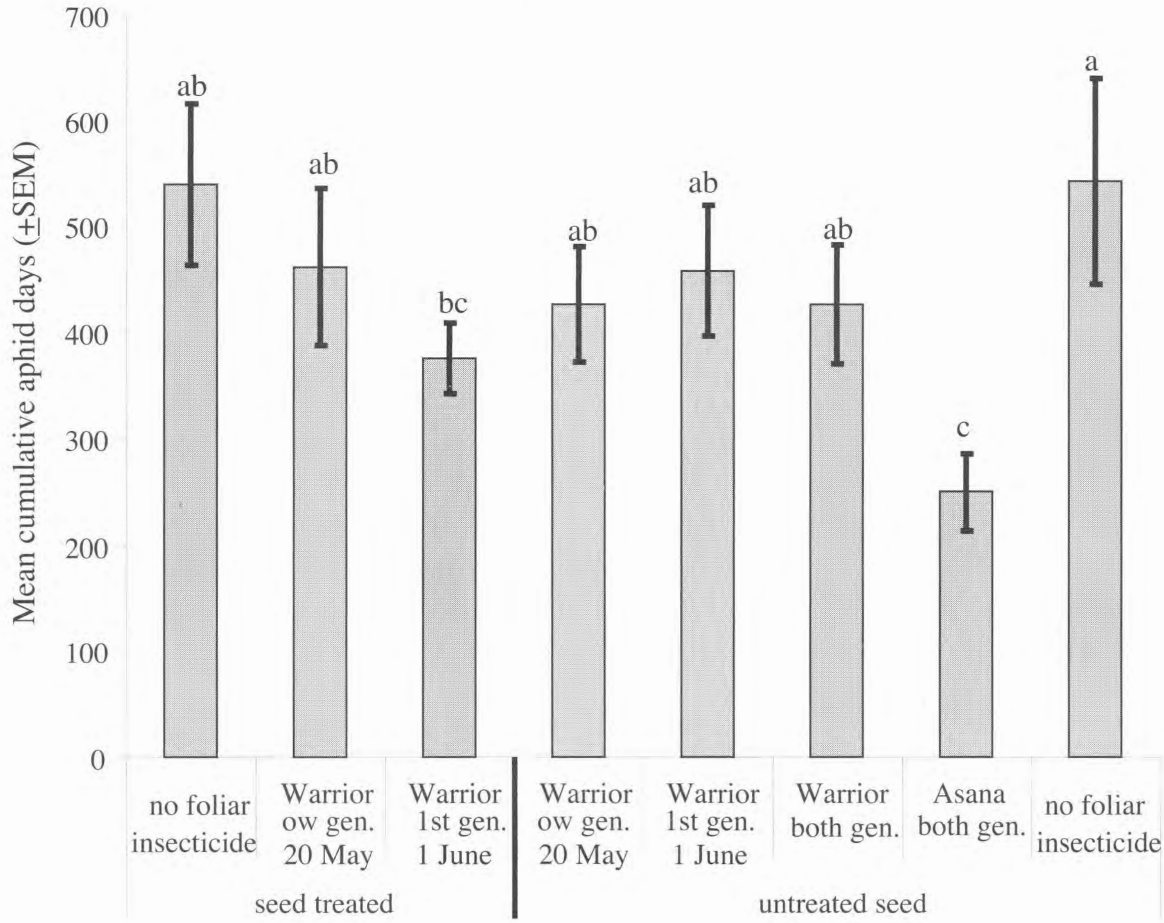

Figure 3. Impact of multiple tactics for bean leaf beetle management as control on cumulative soybean aphid days. Treatments include untreated and treated (Cruiser, thiamethoxam, Syngenta) soybean seeds that was treated with and without a foliar insecticides (Warrior, lambda-cyhalothrin, Syngenta and Asana, esfenvalerate, DuPont). The foliar insecticides were applied on 20 May, targeting the overwintering generation (ow gen.), 1 June targeting the first generation (1^{st} gen), or both generations of bean leaf beetles. Means labeled with a unique letter were significantly different (P=0.05).

Results Again, we observed low populations of soybean aphids across the eight treatments, well below the 250 aphid/plant threshold (fig. 3). Despite these low populations we did observe significant treatment affects ($F = 2.93$, $df = 7, 49$; $P = 0.01$). Only two treatments had significantly lower aphid populations than the control, treatment 3 (Cruiser treated seed and Warrior applied at the emergence of 1st bean leaf beetle generation) and treatment 7 (Asana applied at 10d post plant emergence of 1st bean leaf beetle generation). There were not significant differences in yield (bushels/acre) amongst these treatments (J. Bradshaw unpublished data).

4. Development of economic thresholds for soybean aphid management

Materials and Methods We are participating in an ongoing North Central Soybean Research Program (NCSRP, D. Ragsdale pers. comm.) study focused on the development of an economic threshold for application of a foliar insecticide for soybean aphid management. We employed an experimental design that has been replicated across five states in an attempt to refine the current action threshold of 250 aphids per plant (Rice et al. 2004). We expanded this experimental design to address how adjusting planting date, a practice recommended for bean leaf beetle management, may also affect soybean aphids.

Initially we designed our experiment to consist of six treatments that were based on insecticide applications applied when soybean aphid populations reached pre-defined target densities. These treatments were intended for a randomized complete block design with four replicates of each treatment. Due to low aphid populations we attempted to establish treatments with a varied number of replications based on within field population densities. This response to low aphid populations required the number of replications to vary by treatment. Within the early planted soybeans, we included the following treatments with number of replications within parentheses: 1, an untreated control (12 replications), 2, an aphid-free plot treated whenever aphid populations are detected (4 replications), 3, insecticide applied on 30 July 2004 (4 replications) and 4, 6 August 2004 (4 replications). Insecticides were applied in treatments 3 and 4 to establish intermediate aphid populations to determine the impact of varied aphid populations on yield. In the late planted soybeans we established only two treatments, and untreated control (16 replications) and an aphid-free treatment (4 replications).

Plots were established with approximately 1 m buffers between replicates at Iowa State University Research and Demonstration farms Story County (Central farm) research station. Standard soybean variety and conventional agronomic practices of the Iowa State University Agronomic Research Station staff were used. We established early and late-planted plots with the four treatments described above to determine the effect of planting date on soybean aphid management. Our 'early' plots will be planted on 11 May 2004, and our 'late' plots planted on 6 June 2004.

Aphid populations (adults and immatures) established from natural colonization, were sampled each week beginning 8 June 2004 using whole plant counts of 10 plants per plot from a randomly selected site. The mean number of aphids per plant was used to calculate the aphid days for each treatment replication assuming a population doubling time of 2 days (Aphid days =[mean aphids/plant at previous date + current mean aphids/plant/ 2] X 2). Summing the aphid days accumulated during the growing season (accumulated aphid days) provides a measure of the total aphid exposure that a soybean plant experienced. We measured yield by machine harvest of at least 15 row feet. Standard analysis of variance was conducted to determine if insecticide applications significantly affected aphid populations and soybean. Accumulated aphid days was arc-sin transformed to meet the assumptions for analysis of variance (ANOVA).

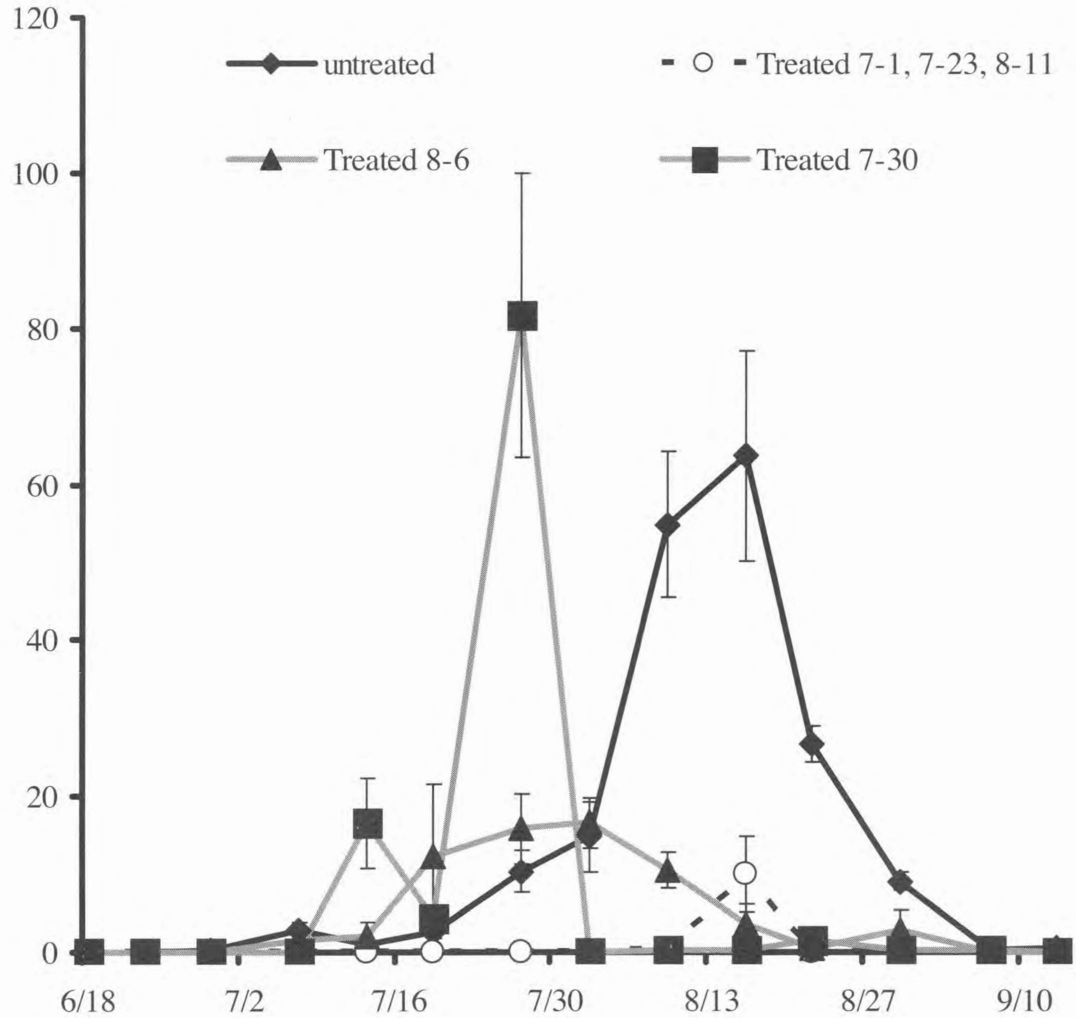

Figure 4. Soybean aphid populations in Story County Iowa during 2004 on soybeans planted on 11 May.

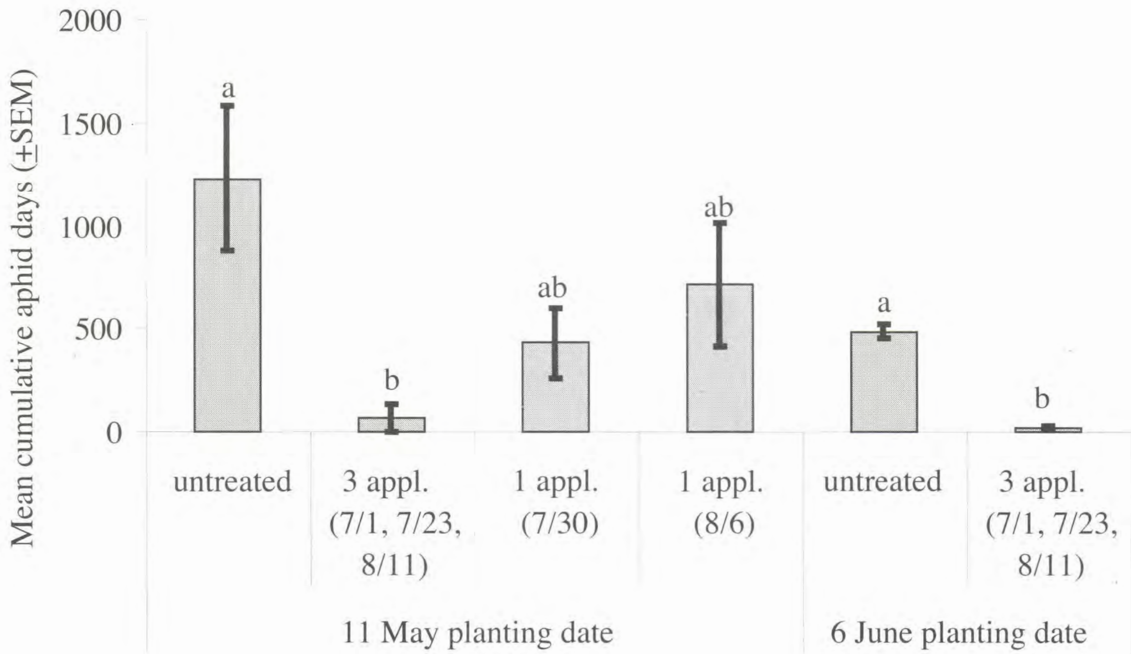

Figure 5. Cumulative aphid days experienced in Story County during the 2004 growing season in untreated plots and plots treated with an insecticide (Warrior) at various times. Within each planting date, means labeled with a unique letter were significantly different (P=0.05).

Results In central Iowa we observed very low aphid populations during 2004 (fig. 4), below the current recommended threshold of 250 aphids per plant. To determine if low aphid populations can impact soybean yields, insecticide applied on 30 July and 6 August in the early planted soybeans resulted in intermediate populations that were below our untreated plots, but more than those in the aphid-free plots (fig. 5). Because soybean aphid populations were so low in the later planted soybeans we did not attempt to produce intermediate densities. By the end of the growing season, the insecticide treatments resulted in a significant differences in accumulated aphid days in both the early planted ($F = 4.19$, $df = 3, 17$; $P = 0.02$) and late planted ($F = 86.48$, $df = 1, 19$; $P = 0.001$) soybeans. Despite these differences in aphid densities, we did not observe an impact of accumulated aphid days on yield (fig. 6) in either the early ($F = 0.13$, $df = 1, 17$; $P = 0.94$) or late ($F = 0.65$, $df = 1, 19$; $P = 0.43$) planted soybeans.

Discussion

Our findings from 2004 suggest that low aphid populations (<250 aphids/plant, fig. 5) had little impact on soybean yield (fig. 6). These low populations may have an indirect effect on yield through disease spread. At printing we have not yet measured the presence of virus in soybean aphid infested and uninfested soybeans. Given the limited impact of low aphid populations on yield, prophylactic treatment of soybean aphids with a seed treatment or an insecticide applied with a post-emergent herbicide may have limited value during years like 2004 when aphid populations are low. Such treatments provided limited protection in 2003 (Fig. 3), when region-wide aphid populations were low. The cyclic nature of soybean aphid populations between years within North America during the last five years suggest that it is likely their numbers will be greater in 2005 than in 2004. To what extant early season treatments can prevent large populations from developing during years of high soybean aphid immigration is not known.

We have some concern that the residual activity of seed treatments and insecticides applied early in the growing season (May and June, Fig 1, and Fig. 3) may not be sufficient to provide protection against soybean aphids that immigrate to soybeans in late July and August. A factor contributing to reduced efficacy is the method of insecticide application. When insecticides are applied to reduce the potential for drift, as when an insecticide is tank-mixed with a post-emergent herbicide (HBP), the coverage within the plant canopy may not be sufficient to reach soybean aphids that are feeding throughout the plant. When we compared a pyrethroid applied as a herbicide (HBP) and as an insecticide (IBP, maximizing coverage) we saw a significant difference in aphid survival 14 days post treatment. Interestingly, by maximizing coverage we did not see differences in insecticide efficacy across the type of insecticide used (Fig. 2). Although we tested a limited number of products, these results suggest that how an insecticide is applied may be more important than the type of insecticide used. Optimizing coverage may be critical to rapidly reduce aphid populations so that the direct feeding damage does not continue. In 2005 we will expand upon these results, developing the best management practices for soybean aphid.

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